104 Designing Artificial Heart Valves

PROJECT

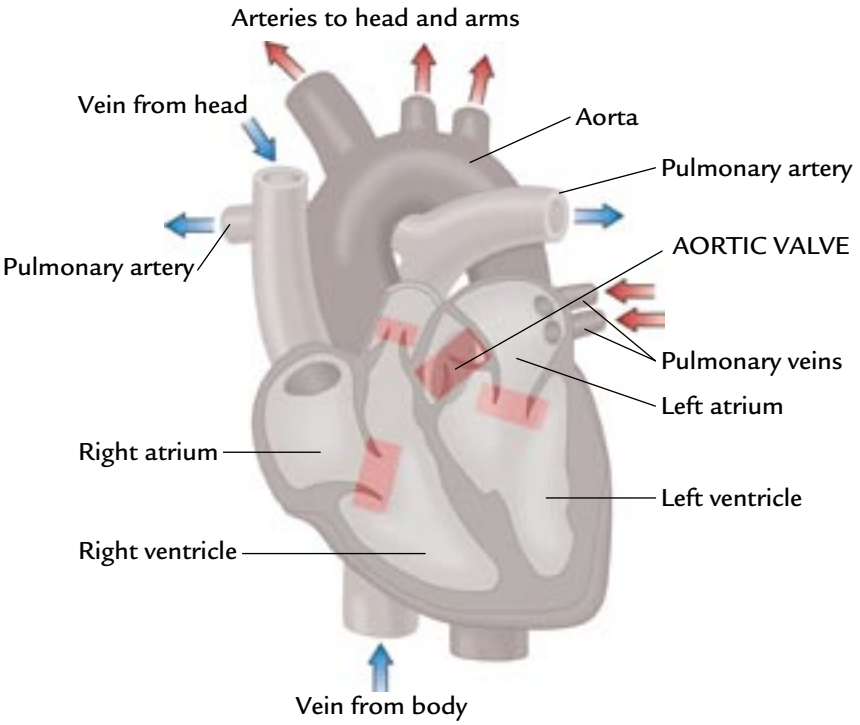
New tools and procedures in the field of medicine are helping people live longer, healthier lives. From eyeglasses and artificial legs to modern surgical techniques, technology is helping more and more people to improve the quality of their lives.

Doctors and bioengineers have worked together to design and engineer artificial heart parts. For example, artificial aortas and valves can now replace damaged structures. The aorta is the main artery carrying blood from the heart. Blood is stopped from flowing back into the heart by the aortic valves. In patients with a genetic condition known as the Marfan syndrome, the aorta often swells. When this happens the aortic valves no longer meet and blood can flow backward into the heart. This is a serious condition, but it can be treated if the swelling is detected in time. If it is not treated, the aorta can swell so much that it bursts.

In this activity, you will design and test simple versions, known as **prototypes**, of a heart valve.

CHALLENGE

How can you design a heart valve prototype out of common materials?



Healthy heart valves control the direction of blood flow.

MATERIALS

For each group of four students

- medium non-latex glove finger(s)
- medium plastic glove finger(s)
- latex rubber dishwashing glove finger(s)
- smaller diameter transparent tubes
- larger diameter transparent tubes
- 2 30-mL graduated cups
- 2 marbles
- 2 small sandwich bags
- 1 sponge or paper towels
- ¼ stick of modeling clay
- 1 stopwatch or access to a clock with a second hand
- 1 large container (for holding water)

For each pair of students

- transparent tape
- 1 plastic cup
- 1 pair of scissors

For each student

- 1 Student Sheet 104.1, "The Design Process"
- 1 Student Sheet 104.2, "Refining Valve Prototypes"

Designing a Prototype

As an assignment for your college course in biomedical engineering, you are asked to design a prototype of a heart valve. Your professors want you and your fellow students to learn more about how the heart works while exploring the design process and the advantages of different valve designs. They require that your valve allow fluid to pass quickly in one direction, while allowing less than 30 mL through every 10 seconds in the other direction.

SAFETY

If you are allergic to latex, be sure to tell your teacher before the activity begins. Do not use the latex gloves if you have an allergic reaction to latex.

SAFETY

During this activity, water may spill on the floor, so walk carefully. Be sure to wipe up all spills.

PROCEDURE

Part A: Exploration

1. With your partner, carefully read the Challenge and "Designing a Prototype" (above). Use the materials your teacher gives you to build two different prototype valves that you think will meet these criteria.
2. Test your prototypes to see if they satisfy the design requirements.
3. Discuss with your partner how you could improve the designs of your prototypes.
4. Decide which valve design best meets the design requirements. Draw and label it on Student Sheet 104.1, "The Design Process."

Part B: Refining Designs

5. Based on the prototype you drew on Student Sheet 104.1, select a factor you could improve in your design. Make this the variable you will test. Then discuss with your partner how you will make a second set of two prototypes to test this variable.
6. Make and test your second set of prototypes.
7. Record your revised designs on Student Sheet 104.2, "Refining Valve Prototypes."
8. Based on your results, make and test a third set of prototypes. Be sure to record your results on Student Sheet 104.2.

Part C: Sharing and Comparing

9. Prepare to present your best valve prototype to the class during an interactive exhibit.
10. Test other students' valve designs during the interactive exhibition. Take notes on which ones would be most likely to work in the human body. For example, you may want to consider how long a valve would have to last or how a valve would work inside less rigid tubes such as blood vessels.

ANALYSIS

1. **a.** Which of the class's designs best met the design requirements?

   b. What other design requirements would be necessary for a valve to be used in a patient?

   c. Which of the class's designs has the most promise to be developed into an artificial valve for use in patients with the Marfan syndrome? Explain your reasoning.

2. **a.** What factors influenced your design?

   b. What do you think would influence a company designing and marketing an actual heart valve?

3. **a.** How is the design process in this activity similar to other kinds of scientific work?

   b. How is the design process in this activity different from other kinds of scientific work?

4. **Reflection:** What did you learn from this activity about being an inventor?